But it is to be noticed that the impulses due to the vibrations of the chemical atoms within a molecule are vastly more frequent than the molecular impulses; and it appears probable that the vibrations of the chemical atoms set up during an encounter will rapidly decay, even in case they do not themselves directly originate radiations. The vibratory energy of this kind may then be changed almost instantly into that of vibration of the ultimate atoms.

According to the hypothesis which we are now considering, the temperature of the body and the intensity of the radiation depend solely on the vibratory energy of the ultimate atoms; but, since these ultimate atoms are assumed to be in all respects equal, they vibrate under the action of the same forces, and have the same degrees of freedom and constraint within the chemical atoms of one element as they do within those of a different element. Hence it appears, that if the ultimate atoms of two different gases have the same vibratory energy (i.e., cause vibrations of the same intensity), so that the flow of radiant energy is the same from all the ultimate atoms of each gas, then there will be no disturbance of this equilibrium when these gases are mixed; in which case the distribution of energy is effected by molecular encounters, which distribute equal mean amounts of energy to each molecule, instead of by radiations, which distribute equal mean amounts of energy to each ultimate atom.

In attempting to account for the high specific heat of liquids, I have elsewhere given reasons for supposing that it is due to a certain per cent of dissociation, which increases with the temperature. It appears probable, that, although some small amount of dissociation may exist in gases also, there is not so large a per cent as in the liquid state, nor does the per cent necessarily increase with the temperature; for by reason of the free progressive motion in a gas, which does not exist in a liquid, any dissociated atoms have a much better opportunity to recombine; and, as the velocities (especially those of free atoms) increase with the temperature, these opportunities increase, as well as the number of dissociations occurring in a unit of time; so that, at a high temperature, an atom of gas may not stay dissociated so long as at a lower temperature, while in a liquid this interval will not be sensibly affected by the temperature.

It is thought that the law of Dulong and Petit receives reasonable explanation on the hypothesis that the ultimate atoms have each the same kinetic energy at the same temperature, as will be shown in a subsequent paper; but, perhaps the strongest direct evidence in favor of the proposed hypothesis is found in the fact that even the simplest elements, such as hydrogen or mercury, have spectra of several lines at least, showing that the source of the light must be sufficiently complex to be able to vibrate in a number of different ways, such as may well be possible for an atom formed of a number of ultimate atoms, but such as is inconceivable in a molecule consisting of one or two perfectly hard atoms. H. T. EDDY.

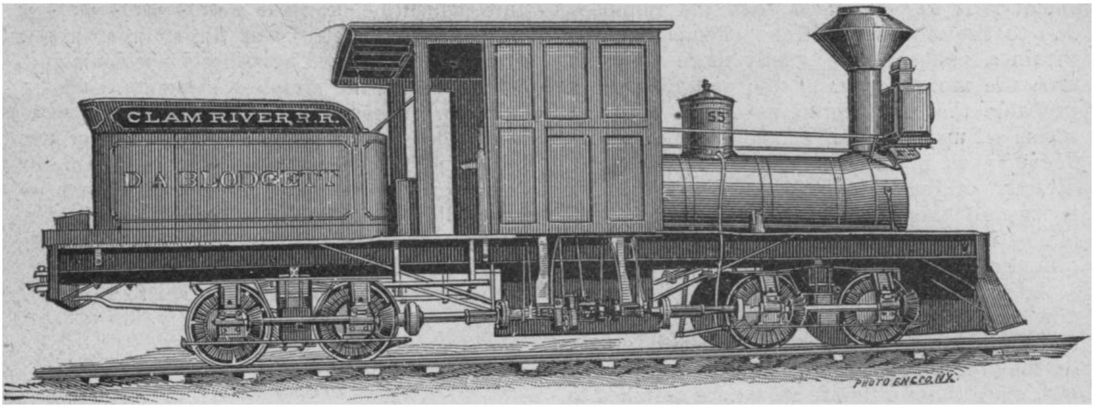
THE NATIONAL RAILWAY EXPOSITION.[1] — IV.

THE exhibit of locomotives was remarkably complete, and comprised engines differing widely in size and power, and adapted for every variety of work; but a certain uniformity of the design of the main features would seem to indicate that locomotive practice has settled down into a certain groove, and that the methods of construction now adopted are so satisfactory that few exhibiters propose to greatly improve upon them by any radical alterations, though one or two of these new departures, such as the Wootten firebox and the Stevens valve-gear, seem likely to come into extensive use.

The main tendency of locomotive design seems to run rather in the direction of larger bearing surfaces and stronger working parts than in any novel methods of construction; while sound and accurate workmanship, and plenty of good material judiciously distributed, are relied on to make a locomotive durable, hard-working, and trustworthy under trying conditions.

Mr. E. Shay of Haring, Mich., exhibits a model of an engine of peculiar construction for 'logging' purposes. These small railways are exceedingly light in construction, and the rails and ties are generally laid directly on the surface of the ground, without any great attention being paid to preliminary grading or alignment; and therefore a suitable locomotive must unite considerable tractive power with great flexibility of wheel-base, and a small weight, on any one pair of wheels. Mr. Shay accomplishes this by using a Forney type of locomotive, having a pair of drivers under the barrel of the boiler, and a four-wheel truck, carrying the tank and fuel, behind the firebox. All the wheels being made of the same diameter, a pair of vertical engines are secured to one side of the firebox, working a longitudinal shaft which

[1] Continued from No. 25.



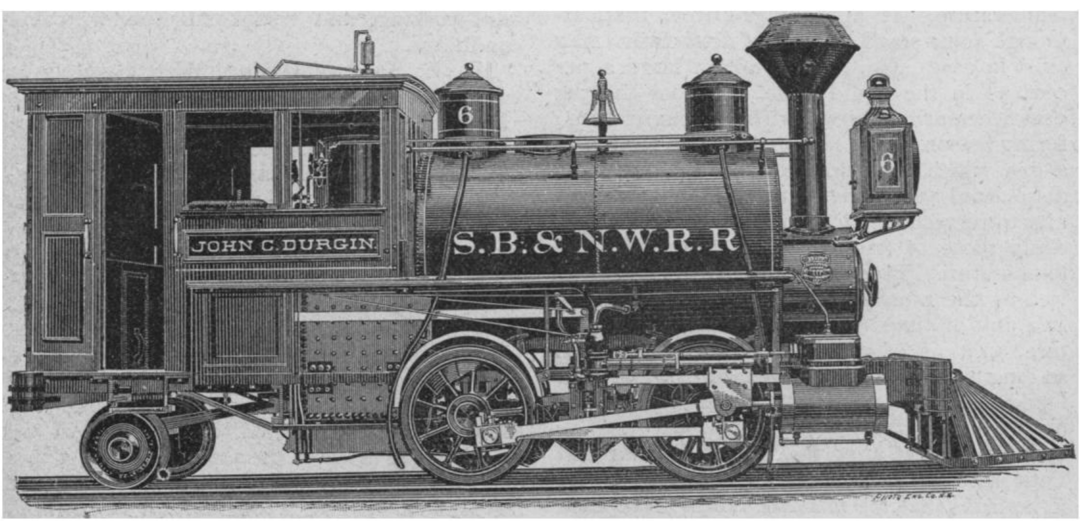
LOGGING LOCOMOTIVE WITH GEARED DRIVING-WHEELS.

runs beside the wheels. Bevel pinions on this shaft engage bevel wheels on the hubs of the wheels, and, as the shaft is provided with universal and telescopic joints, the whole of the wheels can be driven simultaneously, no matter how sharp the curve over which the engine may be running; and, owing to the interposition of gearing, comparatively small-sized cylinders are sufficient to enable the engine to haul very heavy loads, and yet run sufficiently fast for the nature of the work.

Mr. Shay informs us that nearly a hundred of these engines are at work, some on wooden rails, and that they are giving great satisfaction. The mode of driving appears to be novel, and, despite some complexity, is free from many of the disadvantages of the Fairlie system, which also utilizes the adhesion of radiating axles.

Messrs. H. K. Porter & Co. of Pittsburgh, Penn., also exhibit an engine specially adapted for logging railways. Ordinary methods of construction are, however, followed; and the consequent greater simplicity is of great advantage where the work for a few months in the year is very severe, and no repair-shops are situated within convenient distance. The engine exhibited is of the following dimensions, and is calculated to work safely on a rail weighing only thirty pounds per yard: —

Cylinders, diameter and stroke	10 in. × 16 in.
Driving-wheels, diameter	36 in.
Truck-wheels, diameter	22 in.
Rigid wheel, base	5 ft. 3 in.



LOGGING LOCOMOTIVE EXHIBITED BY H. K. PORTER & CO.

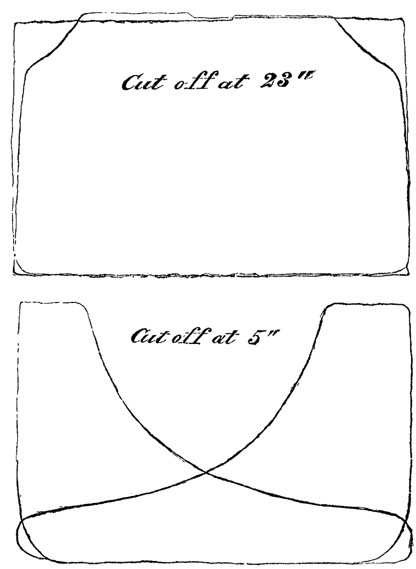
Total wheel base	13 ft. 4 in.
Weight in working order	31,000 lbs.
Weight on drivers.	26,000 lbs.
Water-capacity of tank	500 gallons.

Messrs. Porter state that a similar engine, working day and night on a road 11 miles in length, with grades of 53 feet per mile, has handled 350,000 feet of logs in 24 hours, running about 180 miles in that time.

The engine exhibited is well designed, and the workmanship is fully equal to that on a first-class main-line engine.

The Cooke locomotive works of Paterson, N.J., exhibit an engine for the Southern Pacific railroad which is believed to be the largest locomotive in the world, the cylinders being 20 inches diameter by no less than 30 inches stroke. The designer of this engine, Mr. N. I. Stevens, general master mechanic of the Central Pacific railroad, is, however, building a still larger engine at the company's shops at Sacramento, Cal., the cylinders of which measure 21 inches by 36 inches. This latest development will exert a tractive force of 278 pounds for every pound per square inch average pressure on the pistons; that is to say, with an average pressure on the pistons of 100 pounds per square inch throughout the stroke, this engine would exert a tractive force or pull of 27,800 pounds, less the internal friction of the working-parts of the engine. Whether the average drawbar of the average freight-car is capable of safely standing such a strain is a question which experience will probably solve in a direction unfavorable to weak draw-gear. Apart from their immense size, these engines are interesting as being fitted with a novel form of valve-motion. The engine exhibited has four slide-valves to each cylinder, two main valves, and two riding cut-off valves. An excellent diagram is obtained, the cut-off being sharp, and the compression very slight; and the gear seems well adapted to a slow-running freight-engine. In the later and larger engine, but two valves are employed, and but one eccentric; motion being taken from the engine crossbead. The results of this simpler gear promise to be equally good, and the trial-trip of this engine will be looked forward to with great interest.

The Grant locomotive works are the makers of the only engine which departs from the sober suit of black in which its competitors are arrayed; and further examination shows that its peculiarities are not confined to the outside appearance, but extend to the fuel to be used, which is entirely novel in character. The inventor, Dr. Holland, proposes to raise steam by means of the combustion of decomposed water. The heat evolved by burning naphtha is used to separate the oxygen and hydrogen in superheated steam; and, the carbon of the naphtha kindly uniting with the oxygen thus set free, the hydrogen is burnt by means of oxygen obtained from atmospheric air. The inventor states that the only products of this combustion are carbonic acid and water, the nitrogen disappearing in some mysterious manner not yet fully understood. The old fallacy that water can be decomposed and then reunited, with a positive advantage as regards heat, is here again illustrated; while the strong smell of burning naphtha during the trial of the engine in the exposition indicated that this convenient auxiliary was used to a considerable and probably wasteful extent.



Indicator diagrams obtained on locomotive built at the Cooke locomotive works.

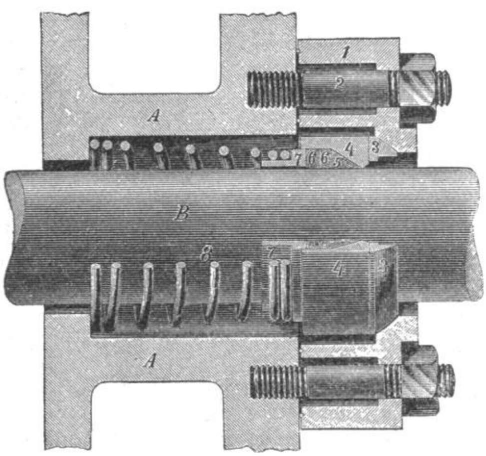
The Philadelphia and Reading railroad exhibit a fast passenger-engine fitted with Woottens' patent firebox, which is adapted to burn any waste or inferior quality of fuel. Reversing the usual practice on locomotives, the combustion on this engine is slow, owing to the enormous area of the grate (72 square feet), instead of a small one (16 or 17 square feet), while the blast is not severe, and the fire is one-third the usual thickness (4 inches instead of 10 or 12 inches); the result being a less vivid combustion, the interior of the fire-box being dull red in place of the white heat usual when

a locomotive is at work. Trials at Chicago seemed to indicate that the engine was capable of maintaining steam with almost any kind of fuel, and that the lignite and inferior coal of the new north-west, which often contains only thirty-five per cent of carbon, can therefore be utilized under locomotives.

The slow combustion does not produce a heat intense enough to fuse the slag, and therefore the firebars keep clean and free from clinker; and it need hardly be pointed out that this is an important practical consideration in dealing with fuel which contains over fifty per cent of ash.

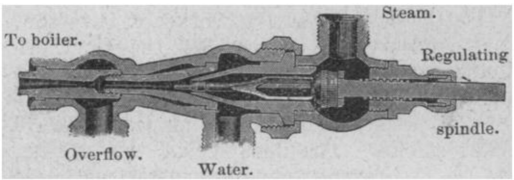
The large grate area is obtained by placing the fire and grate bars completely over the driving-wheels, where plenty of width is obtainable; and the firebox is accordingly made no less then 8 feet wide inside, instead of the usual 33 inches. It might be anticipated that the increased height of the centre of gravity would tend to make the engine unsteady at a high speed; but a precisely opposite result is obtained, as the engine rides with remarkable steadiness and smoothness, even at the highest speeds.

The Shaw engine has been so often described, and been so prominently before the public, that it is only necessary to say here, that, though exhibited at the Chicago exposition, want of time prevented any proper scientific tests being made to ascertain the real value of the invention.



METALLIC PACKING FOR PISTON-RODS.

Various forms of metallic packing for piston-rods are now being extensively used with ex-excellent results, the wear of both rod and packing being very slight, while the use of anti-friction metal obviates the frequent renewals necessary with hemp, rubber, and other packings which are destroyed by heat rather than by wear. In the packing which we illustrate, provision is made for any inaccuracy in fitting by allowing the piston-rod some play in the stuffing-box; the vibrating cup, 4, sliding on the ball and socket ring, 3. As the packing rings are pressed to their work by a spring, it is impossible for a careless engineer to screw his packing too tight, or to make it bear on one side only of the rod.



MACK'S IMPROVED LIFTING INJECTOR.

The National tube-works of Boston, Mass., exhibited an injector at work, which possessed some points of novelty, and appeared to be well adapted for use on locomotives working with bad water. The very fact that a simple arrangement of hollow cones can enable steam to lift and force water into a boiler working at the same pressure is in itself a remarkable paradox; but Mack's injector, as shown at work in the exposition, forced a small quantity of water into a boiler working at two hundred pounds per square inch when the injector itself was only supplied with steam of half that pressure. The apparatus was so arranged that the quantity of water forced against different boiler-pressures by the same pressure of steam could be readily gauged; and the results were interesting as showing what a large range of work can be performed by an apparatus which has no moving parts. The injector is made in several pieces, so that it can be readily taken apart, and cleaned of scale deposited by hard or lime water. When the injector is started, the water is lifted by means of a jet of steam, which rushes through a very fine hole running longitudinally through the centre spindle; the injector becomes full of water, which escapes at the overflow; the regulating spindle is then screwed back, and the large volume of steam thus admitted is condensed by the water already in the injector, mingles with it, and the momentum of the steam due to its great velocity (some five thousand feet per minute) drives the combined steam and water into the boiler.